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ABSTRACT

The major purpose of this study was to determine the characteristics and needs of new female engineering students and to develop or modify programs to meet their needs. The study surveyed a nationwide sample of male and female engineering students of 16 selected universities and colleges to identify differences between these two groups of students and to collect accurate enrollment and retention data for this sample. Included are six chapters: (1) an overview of the study; (2) a summary of the survey results; (3) an analysis of enrollments and of retention; (4) a comparison of the survey population with the population of the United States' university freshmen; (5) a comparison of black women and white women engineering freshmen; and (6) policy implications for engineering colleges. A list of references, published reports of the project, and reports submitted to ERIC are also presented. (HM)

FEMALE ENGINEERING STUDENTS -- ATTITUDES, CHARACTERISTICS, EXPECTATIONS, RESPONSES TO ENGINEERING EDUCATION

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FEMALE ENGINEERING STUDENTS--

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FINAL REPORT

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In addition to the author, the research group at Cornell included Malcolm S. Burton, Robert E. Gardner, David C. Johnson, Howard Kramer, Judith Long Laws, and Lawrence Williams. David Chapman was the statistical consultant.

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1. AN OVERVIEW

This study resulted from an interest in the characteristics and experiences of women students in engineering. Women were only about 1% of engineering students until the early 1970's. At the start of this decade, however, women began to enroll in engineering at steadily increasing rates. The increase in the number of women in engineering colleges presented both an opportunity and a challenge to engineering education. The opportunity was to diversify and increase the engineering student population through the addition of a talented group of new students. The challenge was to determine the characteristics and needs of these new women students and to develop or modify programs to meet their needs.

This study had two major objectives. The first was to identify the characteristics and needs, both academic and non-academic, of incoming men and women students, and the changes in these areas after one and two years in an engineering program. The second was to collect accurate enrollment and retention data for male and female engineering students at each one of a probability sample of institutions. Thus the study focused on the determination of students' characteristics and experiences (see chapters 2 through 5 of this report). Based on our findings, we also made recommendations to engineering colleges for new or modified programs (chapter 6).

The study surveyed a nationwide sample of male and female engineering students to assess the differences between these two groups of students. We also obtained enrollment and retention data for this sample. We turn now to

a description of the research methodology.

A. Survey Schedule

Two entering classes of first-time engineering freshmen were surveyed, the fall 1975 and fall 1976 entering classes. Surveying two classes allowed us to identify (1) those differences between men and women that were the same for two classes, and (2) the differences between the fall 1975 and fall 1976 classes. In both years, freshmen were surveyed at the beginning and at the end of the academic year in order to determine characteristics at college entry, freshman year experiences, and changes in student characteristics during the freshman year. The students who entered in fall 1975 were also surveyed at the end of their sophomore year in an attempt to determine changes in student characteristics between the end of freshman year and the end of the sophomore year.

The survey schedule and the populations surveyed are listed in figure 1.

Figure 1. Survey Schedule.

Survey	Period	Population
1	Fall 1975	Fall 1975 entering class
2	Spring 1976	Fall 1975 entering class
3	Fall 1976	Fall 1976 entering class
4	Spring 1977	Fall 1976 entering class
5	Spring 1977	Fall 1975 entering class

B. Population

We wanted to include in the study all colleges and universities which enrolled a substantial number of freshman women in engineering. We decided to use "thirty freshman women enrolled for bachelor's degree programs in engineering in fall 1975" as the minimum requirement for including a school.

Only 41 schools met this requirement (Engineering Manpower Commission of Engineers Joint Council, 1975). In addition, we included a predominantly Black institution because minority students were of special interest in the survey phase of the study. Consequently, the survey population consisted of all first-time engineering freshmen who entered one of these 42 institutions in the 1975 or 1976 fall term. These 42 institutions are listed in table 1. Forty of the institutions in the population are universities or branches of universities; the other two are professional schools.

C. Sample

A probability sample of sixteen of the forty-two schools was selected for inclusion in the study. Four were chosen with certainty because of characteristics which were of interest, e.g., the racial background of the students and special educational programs. Four others were chosen with certainty because they enrolled the largest numbers of women in 1974. At these eight certainty schools, all women freshmen in engineering and ten per cent of the men were included in the sample. The male students were selected randomly from class lists or admission lists. The eight schools selected with certainty are self-representing schools. That is, in computing survey estimates, the students in the sample from these schools only represent other students at their own school, rather than representing students at other schools as well.

The remaining thirty-four institutions were divided into four strata which were approximately equal in total female enrollment. Two institutions were then selected at random from each stratum, giving a total of eight randomly selected schools. The four strata were defined in two grouping operations, the first based on size of female enrollment and the second based on region. The students at the eight randomly selected schools represent the other schools in their stratum. This representation is based on the overall student selection probabilities. All of the women freshmen and a proportion of

Table 1. Schools in the Population

Certainty Schools

Due to Special Characteristics

Cornell University
General Motors Institute
Howard University
University of Puerto Rico, Mayaguez Campus

Due to Size of Female Enrollment

Texas A & M University, Main Campus
Purdue University, Main Campus
Pennsylvania State University, Main Campus
University of Illinois, Urbana Campus

Non-Certainty Schools

Larger Female Enrollment

Coasts	Central
Georgia Institute of Technology, Main Campus	Ohio State University, Main Campus
Carnegie-Mellon University	University of Michigan at Ann Arbor
University of Pittsburgh, Main Campus	Michigan Technological University
Virginia Polytechnic Institute and State University	Iowa State University of Science and Technology
University of California at Berkeley	Michigan State University
University of California at Davis	University of Texas at Austin
	University of Tennessee at Knoxville

Smaller Female Enrollment

Coasts	Central
University of Washington	University of Colorado at Boulder
University of Virginia, Main Campus	Montana State University
Rensselaer Polytechnic Institute	Vanderbilt University
Lehigh University	University of Missouri at Columbia
University of California at Los Angeles	University of Missouri at Rolla
Duke University	Northwestern University
University of Arizona	Washington University (St. Louis)
Princeton University	University of Wisconsin at Madison
North Carolina State University at Raleigh	Colorado School of Mines
State University of New York at Buffalo, Main Campus	University of Illinois, Chicago Circle Campus
Stanford University	

the men comprised the sample at these schools. The proportion of men selected at each school depended on the number of schools in the stratum. The sampling rate used for men at each school was determined in such a way that each man in the sample was selected with a probability of 10%. Therefore, each man selected into the sample represented himself plus nine other men from the schools in his stratum.

D. Survey Participation

Schools which participated in the surveys are listed in table 2. All of the eight schools selected with certainty participated in the first survey (survey of freshmen in fall 1975). However, two of the randomly selected schools in one stratum (Iowa State University and the University of Texas at Austin) declined to participate and were replaced by back-up schools from their stratum (Michigan State University and the University of Tennessee at Knoxville). In selecting back-up schools an attempt was made to choose schools from the stratum whose characteristics were most like those of the non-participating schools.

The second survey (survey of freshmen in spring 1976) included students at fifteen of the sixteen schools that participated in the fall 1975 survey. One of the eight randomly selected schools (the University of Tennessee at Knoxville) did not participate in this and subsequent surveys.

The third and fourth surveys involved a new population, i.e., freshmen who entered engineering at the 42 institutions in fall 1976. Fourteen schools, including thirteen of the original sixteen schools which comprised the fall 1975 sample, participated in the fall 1976 freshman survey. Michigan Technological University replaced the University of Tennessee at Knoxville. However, one of the eight schools selected with certainty (Texas A&M University) and one of the eight randomly selected schools (Vanderbilt University) did not participate in fall 1976.

Table 2. Schools Participating in Surveys

School **	Survey Administration * #1 Fall '75 Freshmen	#2 Spring '76 Freshmen	#3 Fall '76 Freshmen	#4 Spring '77 Freshmen	#5 Spring '77 Sophomores
1. Cornell University	X	X	X	X	X
2. General Motors Institute	X	X	X	X	X
3. Howard University	X	X	X		
4. University of Puerto Rico	X	X	X	X	X
5. Texas A&M University	X	X			X
6. Purdue University	X	X	X	X	X
7. Pennsylvania State University	X	X	X	X	X
8. University of Illinois at Urbana	X	X	X	X	X
9. Carnegie-Mellon University	X	X	X	X	X
10. University of California at Berkeley	X	X	X	X	X
11. Michigan State University	X	X	X	X	X
12. University of Tennessee at Knoxville	X				
13. University of Virginia	X	X	X	X	X
14. Lehigh University	X	X	X	X	X
15. Vanderbilt University	X	X			X
16. Colorado School of Mines	X	X	X	X	X
17. Michigan Technological University			X	X	
TOTALS	16	15	14	13	14

* Surveys 1,2, and 5 involved the first cohort of students (fall 1975 freshmen). Surveys 3 and 4 involved the second cohort (fall 1976 freshmen).

** Schools 1 to 8 are certainty schools. Schools 9 to 17 are randomly selected schools. Michigan State University and the University of Tennessee at Knoxville were back-up schools for the two randomly selected schools which declined to participate. Michigan Technological University replaced the University of Tennessee at Knoxville in fall 1976.

Thirteen schools participated in the fourth survey (of freshmen in spring 1977). These included all but one of the fourteen schools which participated in the fall 1976 survey. Unfortunately, the survey responses from Howard University were apparently lost in the mail.

Finally, fourteen schools participated in the fifth survey. This survey of sophomores in spring 1977 included the students who were fall 1975 entrants. The fourteen schools included the fifteen which participated in the second survey, excepting Howard University.

Table 3 gives the estimated survey population sizes, the survey sample sizes, the number of respondents, and the response rates for each of the five surveys. For comparisons between students' responses to surveys 1 and 2, the population includes all students who enrolled in fall 1975 and remained in school in spring 1976. For such comparisons, the population and sample are those given in table 3 for survey 2. Similarly, for comparisons involving surveys 1 or 2 with survey 5, the population and sample are those given in table 3 for survey 5. Finally, for comparisons between students' responses to surveys 3 and 4, the population and sample are those given in table 3 for survey 4.

E. Survey Analyses

Data were analyzed in terms of estimates of the proportions of men and of women in the population who would have given a particular response to a question. In order to make valid estimates of these population proportions, the data were subjected to statistical weighting procedures. Each respondent was assigned a weight having two components. The first was based on the overall student selection probability and adjusted the sample to represent all students in the population. The second component was an adjustment for student nonresponse. For those surveys in which fewer than sixteen schools participated, the weight had a third component to adjust for non-participation of the school or schools.

Table 3. Survey Population Sizes, Sample Sizes, Numbers of Respondents, and Response Rates.

		Survey #1 Fall 1975 Freshmen	Survey #2 Spring 1976 Freshmen	Survey #3 Fall 1976 Freshmen	Survey #4 Spring 1977 Freshmen	Survey #5 Spring 1977 Sophomores
Estimated Population Size	Men	16370	15211	17964	16330	12000
	Women	2917	2528	3412	3070	1977
	Total	19287	17739	21376	19400	13977
Sample Size *	Men	1637	1383	1618	1467	1128
	Women	1276	1079	1315	1075	806
	Total	2913	2462	2933	2542	1934
Number of Respondents	Men	905	496	1009	580	308
	Women	773	487	852	535	303
	Total	1678	983	1861	1115	611
Response Rates **	Men	55.3%	35.9%	62.4%	39.5%	27.3%
	Women	60.6%	45.1%	64.8%	49.8%	37.6%
	Total	57.6%	39.9%	63.5%	43.9%	31.6%

* The sample was selected from 16 schools for Survey #1, 15 for Survey #2, 14 for Surveys #3 and #5, and 13 for Survey #4.

** The response rates are based only on student participation in cooperating schools. These rates do not reflect any nonparticipation of schools.

The precision of the estimated proportions was gauged by obtaining estimates of the standard errors of these estimated proportions. The standard error of an estimated proportion is a measure of the variability that the estimated proportion would have in repeated samples of the same type from this population. We also estimated the precision of the difference between the estimated proportions for men and women. By comparing the difference in the estimated proportions for men and women with the estimated standard error of the difference, we determined whether a difference in estimated proportions was statistically significant. In this report, .01 will generally be taken as the level of significance. Significance at the .01 level means that there was only about one chance in a hundred that the magnitude of the difference in estimated proportions would be as high or higher than that found, if the population proportions were equal.

Complete results of each survey have been submitted to the ERIC system. The reports and their ERIC document reproduction service numbers are listed in the Bibliography of Project Reports. The survey results for the population are discussed in subsequent sections of this report.

For each school in the sample, we analyzed the unweighted responses of men and of women to each survey question using chi square analysis. These results have been provided to the participating schools. They are far too voluminous for inclusion in this report.

F. Generalizability of the Survey Results

The survey results are generalizable only to the 42 schools in the population and not to other schools. In particular, they should not be generalized to two-year and four-year colleges, because of differences both in type of institutions and in the college environment when the proportion of women is substantially smaller than at the institutions in the study population.

2. CHARACTERISTICS OF MEN AND OF WOMEN ENGINEERING STUDENTS

This chapter presents a summary of the survey results. The results are organized as follows: (a) fall surveys of incoming freshmen; (b) spring surveys of freshmen; (c) selected differences between the fall 1975 and fall 1976 freshman populations; (d) spring 1977 sophomore survey.

A. Fall Surveys of Incoming Freshmen

The questionnaire administered in the fall of 1975 consisted of Part I of the College Student Questionnaire developed by the Educational Testing Service (200 items) and a thirty-item questionnaire designed for this study. The questionnaire administered in the fall of 1976 consisted of 80 items, including a number of items adapted from the College Student Questionnaire, with the permission of the Educational Testing Service. Single copies of the questionnaires are available from the author.

The fall 1975 and fall 1976 surveys were first analyzed separately. In tables 4 to 7 we report differences between the responses of men and of women students which were statistically significant at the .01 level for both the fall 1975 and fall 1976 survey populations. These differences appear to be stable since they were significant differences in both years. Results are categorized as follows: (1) background, (2) expectations, (3) activities, and (4) attitudes.

Differences in Background (Table 4) Women students, who tended to be younger than the men, had first considered engineering for their major field somewhat later than men had. Women's parents tended to be somewhat more highly educated than men's, as indicated by the fact that high school was the highest level of education for larger proportions of men's parents than of women's.

Table 4. Responses Indicating

Differences in Backgrounds of Men and Women

	Estimated Proportions			
Survey:	Fall 1975		Fall 1976	
RESPONSES — Group:	Men	Women	Men	Women
1. Seventeen years old or younger	22%	28%	13%	20%
2. First considered majoring in engineering in last two years	48	66	38	52
3. Highest level of father's education				
Finished nigh school	20	15	21	16
4. Highest level of mother's education:				
Finished high school	36	25	36	32
Some college	16	19	16	21
5. Subject most enjoyed in high school:				
Mathematics	38	49	32	49
Sciences	39	32	40	27
Shop or commercial	3	1	6	1
6. Subject least enjoyed in high school:				
English	30	19	32	20
Foreign language(s)	28	17	27	12
Physical education	6	13	5	12
7. High school class standing:				
Top 2%	20	40	19	37
Top 5%	18	24	17	23
Top 20 to 50%	37	17	34	17
8. High school grade average of A or A-	48	70	52	73
9. Spent two or more hours per day on home-work during senior year	41	57	40	53

There were a number of differences in attitudes toward courses taken in high school. Most important is the fact that women tended to prefer mathematics courses to science courses in high school, whereas men tended to prefer science courses. It is evident that women students were superior students in high school.

Differences in Expectations (Table 5) The only consistent difference in major field choice was that about twice as large a proportion of men as of women planned to major in electrical engineering.

Students differed in regard to expectations for their freshman year in college. In particular it is interesting that larger proportions of male students than of females expected to rank in the top 10% of their class, and larger proportions of men than of women expected to obtain an A average. These results, when compared with the actual superiority of women's high school grades, seem to indicate greater levels of self-confidence among the men students. Furthermore, larger proportions of men than of women expected to do better than other students, whereas larger proportions of women than of men expected to perform equally with others.

Students differed in the persons expected to be the greatest influence in their freshman year. Women tended to expect greater influence from women than did men, and men expected greater influence from men than women did.

Differences in Activities (Table 6) Students differed by sex in high school participation in activities and in interest in participating in activities. Women were less likely than men to have received high school athletic awards or to have devoted much time to automotive activities. Women were more likely than men to have participated in music or literary activities. Smaller proportions of women than of men were interested in participating in athletics, and larger proportions of women than of men were interested in participating in school spirit or preprofessional organizations.

Table 5. Responses Indicating Differences in Expectations of Men and Women

RESPONSES	Estimated Proportions			
Survey:	Fall 1975		Fall 1976	
Group:	Men	Women	Men	Women
1. Electrical engineering as chosen major field	20%	10%	20%	8%
2. Expect greatest personal satisfaction from becoming acquainted with wide variety of students	5	9	6	12
3. Expect greatest problem to be meeting and/or relating to members of opposite sex	9	4	9	4
4. Expect to rank in top 10% of freshman class, relative to other engineering students	26	17	21	15
5. Expect freshman grade average of A	18	10	15	9
6. Expected academic performance in comparison with engineering students of own sex:				
Better than most	39	19	39	25
Equal	56	74	55	68
7. Expected academic performance in comparison with engineering students of opposite sex:				
Better than most	44	12	48	18
Equal	50	75	46	69
8. Expect most influence from:				
Female faculty/staff members	2	5	1	3
Female engineering students	3	13	2	10
Male engineering students	29	19	20	16
Other male friends	22	8	29	15

Table 6. Responses Indicating Differences in Activities of Men and Women

RESPONSES	Estimated Proportions			
Survey:	Fall 1975		Fall 1976	
Group:	Men	Women	Men	Women
1. Received no high school athletic awards	43%	62%	45%	59%
2. Spent an hour or less per week on automobile activities	61	89	56	87
3. Did not participate in:				
High school music activities	68	52	66	48
Literary debate, speech, dramatic activities	72	57	67	51
4. Not interested in participating in:				
Athletics	14	28	15	27
School spirit activities	51	36	57	47
Preprofessional organizations	27	16	25	16
5. Preferred outside reading:				
Science, math, engineering	13	3	11	3
Science fiction	17	8	18	10
History, economics, etc.	6	2	7	4
Novels, short stories, etc.	18	57	17	56
Sports, leisure	20	7	20	4
6. Quite or very interested in modern art	12	21	14	24
7. Receives a lot of pleasure from classical music	41	61	38	56
8. Enjoys reading poetry	39	71	41	72
9. Almost always consults with friends on important personal decisions	12	24	16	28
10. Usually or almost always consults with parents on important personal decisions	47	59	51	65

Students differed radically in preferred extracurricular reading, and in interest in modern art, classical music, and reading poetry. Finally, larger proportions of women than of men consulted their friends or family concerning important personal decisions.

Differences in Attitudes (Table 7) Students differed to some degree in attitudes toward graduate study and work. Increased earning potential was important to larger proportions of men than of women as a reason for planning to attend graduate school. Students differed somewhat in preferred work situation and expected source of job satisfaction. In addition, larger proportions of men than of women considered administrative responsibility a very important work requirement.

As indicated in table 7, men and women differed in attitudes toward certain social issues. In addition to issues of national political interest, they differed in regard to campus issues. That is, larger proportions of women than of men believed that colleges should provide assistance to minorities and to women in developing peer support groups. Larger proportions of men than of women indicated that no special assistance should be given to women engineering students.

Finally, men and women expressed different attitudes concerning plans for combining careers and marriage. Not only were there differences between men's and women's preferences for themselves. In addition, women's preferences for their future roles differed substantially from men's preferences for their spouse's roles.

In addition to the items discussed here, there were others which were included on the fall 1975 or the fall 1976 survey, but not on both. A number of these items, relating to characteristics such as Scholastic Aptitude Test scores and parents' income, are discussed in Chapter 4 of this report.

Table 7. Responses Indicating Differences in Attitudes of Men and Women

RESPONSES	Estimated Proportions			
Survey:	Fall 1975		Fall 1976	
Group:	Men	Women	Men	Women
1. Expectation of increased earnings as most important reason for graduate study	10%	4%	11%	3%
2. Preferred type of work situation:				
Own business	9	4	12	4
Public or private research organization	13	21	12	19
3. Most important source of future job satisfaction:				
Prospects of above average income	13	7	11	3
To be helpful to others and/or useful to society	14	26	9	19
A stable, secure future	17	8	25	14
4. Consider it essential or very important to have administrative responsibility	32	26	34	21
5. Probably or definitely plan to join Peace Crops or VISTA	7	14	7	13
6. Fairly or very well informed about political affairs	61	39	68	53
7. In favor of abolition of capital punishment	31	46	25	45
8. Concerned about children having access to obscene literature	39	69	44	58
9. Opposed to decision to bomb Hiroshima	19	41	22	49

Table 7 (continued). Responses Indicating Differences in Attitudes of Men and Women

RESPONSES	Estimated Proportions Survey: Fall 1975 Group: Men	Women	Fall 1976 Men	Women
10. Support college sponsored peer support groups to assist minority engineering students	10%	16%	8%	17%
11. Support special assistance for female engineering students in terms of:				
Peer support groups	7	16	8	14
None of the areas	53	37	42	28
12. Preferred situation for self in ten years:				
Married, no children, full-time job	23	31	29	44
Married, children, full-time job	59	21	52	19
Married, children, part-time job	1	25	2	19
Married, children, unemployed	1	8	0	5
13. Preference for man's role:				
Married, no children, full-time job	23	32	29	44
14. Preference for woman's role:				
Married, no children, full-time job	12	31	15	44
Married, children, full-time job	7	21	4	19
Married, no children, part-time job	9	2	12	2
Married, children, unemployed	31	8	26	5

B. Spring Surveys of Freshmen

The questionnaires administered to freshmen in spring 1976 and spring 1977 focused on students' freshman year experiences and on career plans. They consisted of sixty items designed for this study. These items included a number adapted from the College Student Questionnaire, with the permission of the Educational Testing Service. The questionnaires generally took less than thirty minutes to complete. Only those freshmen who had completed the fall survey and who continued in engineering at their original institution were eligible to complete the spring survey.

The spring 1976 and spring 1977 freshman surveys were analyzed separately. In tables 8 and 10 we report those differences between the responses of men and of women students which were significant at the .01 level for both the spring 1976 and spring 1977 survey populations. Since these differences were statistically significant for both years, they appear to be stable. Differences were found both in freshman year experiences and in career plans.

Freshman Year Experiences (See Table 8) At the end of the freshman year, the students indicated how well they thought they had performed academically, both in relation to students of the same sex and to students of the opposite sex. Once again, men evaluated their work more confidently than women did. Larger proportions of men than of women indicated that they had done better than most other students, whether men or women. Women again tended to rate their performance as being equal to that of other students. Further, larger proportions of men than of women said that they were not anxious during exams.

Since the grades for their first semester courses reported by men and women indicated equal performance levels, these results indicate differences in perceptions of performance, not differences in actual performance. It is helpful to explore these results further.

In table 9 we compare students' responses in spring 1976 concerning their academic performance in relation to students of the same sex and to

Table 8. Responses Indicating

Differences in Freshman Year Experiences of Men and Women

	Estimated Proportions			
Survey:	Spring 1976		Spring 1977	
RESPONSES - Group:	Men	Women	Men	Women
1. Academic performance was better than that of most others of ones sex	39%	25%	36%	26%
2. Academic performance was better than that of most students of other sex	39	23	39	24
3. Not anxious during course exams	15	9	14	7
4. Number of engineering students among three closest female friends:				
None	57	39	53	39
Two	8	15	12	19
5. Consults with close friends on important decisions:				
Almost always	13	32	15	23
Seldom	30	19	33	24
Almost never	13	4	12	7

Table 8 (continued). Responses Indicating Differences in Freshman Year Experiences of Men and Women

RESPONSES	Estimated Proportions			
Survey:	Spring 1976		Spring 1977	
Group:	Men	Women	Men	Women
6. Participation in preprofessional organizations:				
None	77%	58%	78%	58%
To a small extent	19	37	19	36
7. Greatest influence during freshman year:				
Female engineering students	3	10	1	10
Other male friends on campus	26	11	27	17
Other female friends on campus	4	17	4	21
8. Feelings about sex ratio in engineering at ones college:				
Too high a proportion of men	59	25	64	25
Proportions are fine	38	72	32	69
9. Non-required reading:				
Nonfiction in science, math, engineering	10	3	9	1
Novels, short stories, drama, poetry, etc.	13	39	13	41
Nonfiction--sports, leisure, etc.	30	10	24	6

Table 9. Students' Assessment of Relative Academic Performance in Spring 1976.

Category	Men	Women	Significance Level of Difference
1. Performance with respect to members of own sex rated higher than with respect to members of other sex.	7.9%	15.4%	.01
2. Performance rated the same with respect to both sexes.	82.3%	76.2%	.05
3. Performance with respect to members of own sex rated lower than with respect to members of other sex.	8.6%	6.9%	not significant at .01 or .05

students of the opposite sex. Results were similar for the spring 1977 freshman survey. We show the relative proportions of men and of women in three categories: those who (1) rated their performance more highly in comparison with that of students of their own sex than in comparison with students of the opposite sex; (2) rated their performance the same in comparison with both groups; and (3) rated their performance lower in comparison with that of students of their own sex than in comparison with students of the opposite sex. Greater proportions of men than of women considered their academic performance to be the same as that of other men and women. Thus, greater proportions of men than of women appear to consider the two sexes' academic performance to be equal. On the other hand, greater proportions of women than of men had a higher estimate of their academic achievement in relation to that of their own sex than in relation to that of the opposite sex. Thus, greater proportions of women than of men appeared to have a higher opinion of the academic achievement of the opposite sex than that of their own sex. Considering the fact that men's and women's academic achievement did not differ, it is apparent that greater proportions of women than of men underestimated the academic performance of students of their own sex. This result is similar to a finding by Farley that women undergraduates reported themselves to be less intelligent than men rated themselves, although the women received higher grade point averages (Farley, 1974).

Friendship patterns differed by sex. Larger proportions of men than of women had no friends in engineering among their three closest female friends. Also, women were more likely than men to have engineering students as two of their closest female friends. Women students indicated a greater tendency than men to consult with their friends about important decisions.

A larger proportion of men than of women had not participated at all in preprofessional organizations. Women were more likely than men to have participated in these organizations to a small degree.

Persons who were the greatest influence on the students during the freshman year differed by sex. Larger proportions of women than of men indicated that female engineering students or other female friends on campus were the greatest influence. Larger proportions of men than of women said male friends on campus were most influential.

Men were more likely than women to indicate that the proportion of men among engineering students was too large, whereas women tended to indicate that the proportion was just right.

Men and women differed in types of materials preferred for non-required reading, as they had when they entered college.

Career Plans (See Table 10).

Three results concerning careers from the surveys completed at the start of freshman year were obtained at the end of freshman year as well. Larger proportions of men than of women planned to major in electrical engineering. For a larger minority of men than of women, high earnings were the most important reason for their career choice. Also, women were less likely than men to prefer to own their own businesses.

A larger proportion of men than of women agreed that they had understood the nature of an engineering career before they started college.

It appears that the degree of motivation to be engineers changed for larger proportions of women than for men. That is, larger proportions of men than of women were neutral when asked whether they were more strongly motivated to be engineers than they were a year earlier.

Students were asked to indicate a major in engineering or in another area. A larger proportion of women students than of men did not indicate any major field choice in engineering, although there was no single field outside engineering which women chose more often than men did.

Table 10. Responses Indicating

Differences in Career Plans of Men and Women

RESPONSES	Estimated Proportions			
Survey:	Spring 1976		Spring 1977	
Group:	Men	Women	Men	Women
1. Electrical engineering as major	17%	8%	22%	9%
2. Did not indicate a major field in engineering	4	11	3	12
3. High earnings as most important reason for career choice	8	3	9	2
4. Own business as preferred professional work situation	13	5	17	4
5. Agree or strongly agree they understood nature of engineering career before college	42	34	46	36
6. Neutral when asked if more strongly motivated to be an engineer than a year earlier	26	16	28	21
7. 21 to 23 as age to first start full-time professional work	47	63	48	62
8. Age to first start part-time professional work:				
21 to 23	24	14	18	8
30 to 32	0	6	0	4

Table 10 (continued). Responses Indicating Differences in Career Plans of Men and Women

RESPONSES	Estimated Proportions			
Survey:	Spring 1976		Spring 1977	
Group:	Men	Women	Men	Women
9. Age to first stop working for six months:				
24 to 26	2%	8%	3%	8%
27 to 29	3	18	2	17
39 years old or older	33	14	33	12
10. Age to return to full-time work:				
33 to 35	1	8	2	8
36 to 38	1	7	1	8
11. Age preference for having first child:				
Never	4	9	4	13

Women tended to be interested in starting full-time professional work earlier than the men were. Larger proportions of men than of women were interested in starting part-time professional work from 21 to 23 years of age, at the age when most women were interested in starting full-time work. A larger minority of women than of men were interested in starting part-time work from 30 to 32 years of age.

Larger proportions of women than of men were interested in first stopping work from ages 24 to 29, whereas larger percentages of men than women did not want to stop working until they were 39 years old or older. Furthermore, larger proportions of women than of men were interested in returning to full-time work between the ages of 33 and 38.

Finally, a larger minority of women than of men did not plan to have any children.

C. Selected Differences Between Fall 1975 and Fall 1976 Freshman Populations

An important difference between the two populations is that there was a larger percentage of women students in the fall 1976 population than in the fall 1975 population (16.0% vs. 15.1%). There were also differences in the major field selections of the two populations. These differences may be actual, may be due to sampling error, or to differences in the questions used on the surveys. In fall 1975, students chose from a list of eight engineering fields and a number of non-engineering fields. In fall 1976, spring 1976, and spring 1977, the list of major fields included sixteen engineering fields, as well as other fields.

Despite these possible sources of variation in responses, it appears that in 1975-76 there was an actual difference in the percentages of freshman men and women planning to major in mechanical engineering, and no difference in the proportions in 1976-77. For the students who entered engineering in fall 1975, a significantly larger proportion of men than of women planned to

major in mechanical engineering (14.7% of men, 5.5% of women). For this same population, there was a similar difference in the spring of the freshman year. At that time, 18.7% of men and 7.5% of women were interested in mechanical engineering. Both differences between men and women were significant at the .01 level. For the class which entered in fall 1976, there was also a difference in the proportions of men and women choosing mechanical engineering, but these proportions only differed at the .05 level. In this class, 14.5% of men and 9.1% of women chose mechanical engineering. However, in spring of the freshman year, there was no significant difference (at the .05 level) between the proportions of men and women in this class who chose mechanical engineering (16.1% for men, 13.9% for women).

Thus, it appears that there was a difference in the proportions of men and women choosing mechanical engineering as a major for the population which entered in fall 1975, but little if any such difference for the population which entered in fall 1976.

D. The Spring 1977 Sophomore Survey

The questionnaire administered to sophomores in the spring of 1977 consisted of 50 items designed by the research team. A number of the questionnaire items were adapted from Part I of the College Student Questionnaire, with the permission of the Educational Testing Service. The questionnaire generally took less than thirty minutes to complete.

In order to be eligible to complete this survey, students had to have continued in engineering at their original school in spring 1977, and to have completed both the fall 1975 survey and the spring 1976 survey. The survey population, however, included all students who continued to enroll in engineering at their original schools. Thus, although approximately 71% of the men and 77% of the women who were eligible completed the survey, this was only 27% of the men and 38% of the women in the original fall 1975 sample who continued in engineering.

These overall response rates are too low to justify estimating population response proportions for the survey items, or testing the significance of the difference between estimated proportions of men and of women giving a particular response to a question. Similarly, an analysis of changes in students' responses from freshman through sophomore year does not appear to be warranted.

The spring 1977 sophomore survey results may be said to characterize the survey respondents, rather than the intended survey population. Complete results of the spring 1977 sophomore survey are available from the author of this report and from ERIC.

3. ANALYSIS OF ENROLLMENTS AND OF RETENTION

One of the two major objectives of the study was the collection of accurate enrollment and attrition data for male and female engineering students at representative institutions. We will first discuss enrollments and then retention.

A. Enrollments

The enrollment information obtained includes two types of information--enrollments at the institutions in the sample, and estimates of enrollments for the population of 42 schools. Table 11 presents the total first-time freshman enrollments, and the number and percentage of women freshmen, for the schools in the sample for both fall 1975 and fall 1976. These data were obtained from the institutions. Note that there were large variations among schools in total freshman enrollment, numbers of women, and percentages of women.

Purdue University had the largest total freshman enrollment each year, and the largest number of women. Due to criteria for including schools in the population, only Howard University had fewer than 30 women in either freshman class.

General Motors Institute had the largest percentage of women in its freshman class each year. Of the schools which provided the enrollment information, the schools having the lowest percentage of women freshmen were the University of Puerto Rico, the University of Tennessee, and the University of Illinois in 1975, and Michigan Technological Institute, the University of Illinois, and the University of Puerto Rico in 1976.

Estimates of the total numbers of men and women first-time freshmen in engineering in the population of 42 schools have been developed, based

Table 11. Total First-time Freshman Enrollments, Number and Percentage of Women at Each School in the Sample, for Fall 1975 and Fall 1976.

	School	Fall 1975 Total N	Fall 1975 Women	Fall 1975 % Women	Fall 1976 Total N	Fall 1976 Women	Fall 1976 % Women
1.	Cornell University	648	78	12.0%	654	82	12.5%
2.	General Motors Institute	233	60	25.8	361	104	28.8
3.	Howard University	137	20	14.6	111	26	23.4
4.	University of Puerto Rico	767	73	9.5	559	66	11.8
5.	Texas A&M University	976	118	12.1	---	---	----
6.	Purdue University	1477	214	14.5	1752	236	13.5
7.	Pennsylvania State University	591	95	16.1	541	115	21.3
8.	University of Illinois at Urbana	1103	117	10.6	1200	133	11.1
9.	Carnegie-Mellon University	419	74	17.7	361	63	17.5
10.	University of California at Berkeley	350	46	13.1	414	59	14.3
11.	Michigan State University	636	81	12.7	683	118	17.3
12.	University of Tennessee at Knoxville	408	43	10.5	---	---	----
13.	University of Virginia	341	67	19.6	401	82	20.4
14.	Lehigh University	502	58	11.6	499	69	13.8
15.	Vanderbilt University	284	64	22.5	---	---	----
16.	Colorado School of Mines	442	68	15.4	514	71	13.8
17.	Michigan Technological University	---	---	----	879	92	10.5

* Information not available for fall 1976

** Replaced University of Tennessee in fall 1976.

on the enrollments at the schools in the sample. These estimated enrollments have been given in table 3 of chapter 1.

B. Retention

Retention has been a topic of concern in engineering education for many years. Studies of retention in engineering have generally included only male students (Elton & Rose, 1967; Elton & Rose, 1971), or have not distinguished between men and women in the analysis (Elkins & Luetkemeyer, 1974; Foster, 1976; Hanson & Taylor, 1970). Recently, retention has received renewed attention because of the dramatically increased number of women students in engineering. Comparisons of the retention of men and of women students at individual schools have appeared (Davis, 1975; Gardner, 1976; Nemeth, 1975), as has a controversial analysis of the retention of a national sample of students who enrolled in 1968 (Kaufman, 1977). However, no analysis has previously appeared of a large population of engineering students which has a substantial proportion of women students.

This section of the report presents estimated retention rates after 1 1/2 years of college for a population of men and women engineering students who entered college in fall 1975. Further, it presents an analysis of student characteristics related to retention for men and women students who did not continue to study engineering at their original schools.

Method

Population and Sample. The population consisted of all first-time engineering freshmen who entered one of the 42 institutions in the survey population in the 1975 fall term. Women comprised an estimated 15.1% of the population of approximately 19,300 freshman engineering students.

All students selected from the 16 schools chosen for the fall 1975 survey sample who actually enrolled were included in the retention analysis.

This sample included all freshman women in engineering at the sixteen schools and a random sample of the men at these schools. In total, there were 1637 men and 1276 women in the fall 1975 sample.

Results

Retention Rates for Men and Women. Students were considered to be retained if they registered in engineering as freshmen in fall 1975 and remained at the same institution in engineering throughout the spring 1976 term and at the beginning of the spring 1977 term (1 1/2 years). These students will be referred to as the retention group. All other students will be referred to as the non-retention group.

Each of the sixteen schools in the sample reported the names of students in the sample who were not retained. From this data we developed estimates of the population retention proportions for men and women. In calculating these estimates, student weights based on the student selection probabilities were used. The estimated proportions retained at all 42 schools in the population at the start of the spring term of the sophomore year were 73.3% for men, and 67.8% for women. These estimated proportions are significantly different at the .01 level of significance. Thus there was only about one chance in a hundred that the observed difference in proportions would be this large or larger if the population proportions were equal.

The retention rates for the samples at each of the sixteen schools are shown in figure 2. There was clearly a great deal of variation in the retention rates at the various schools. However, most schools had higher retention rates for men than for women. The rates were equal for men and women at one school, higher for women than for men at two schools, and higher for men than than for women at thirteen schools. This difference in the number of schools having higher retention rates for women and those having higher rates for men is significant at the .05 level (sign test).

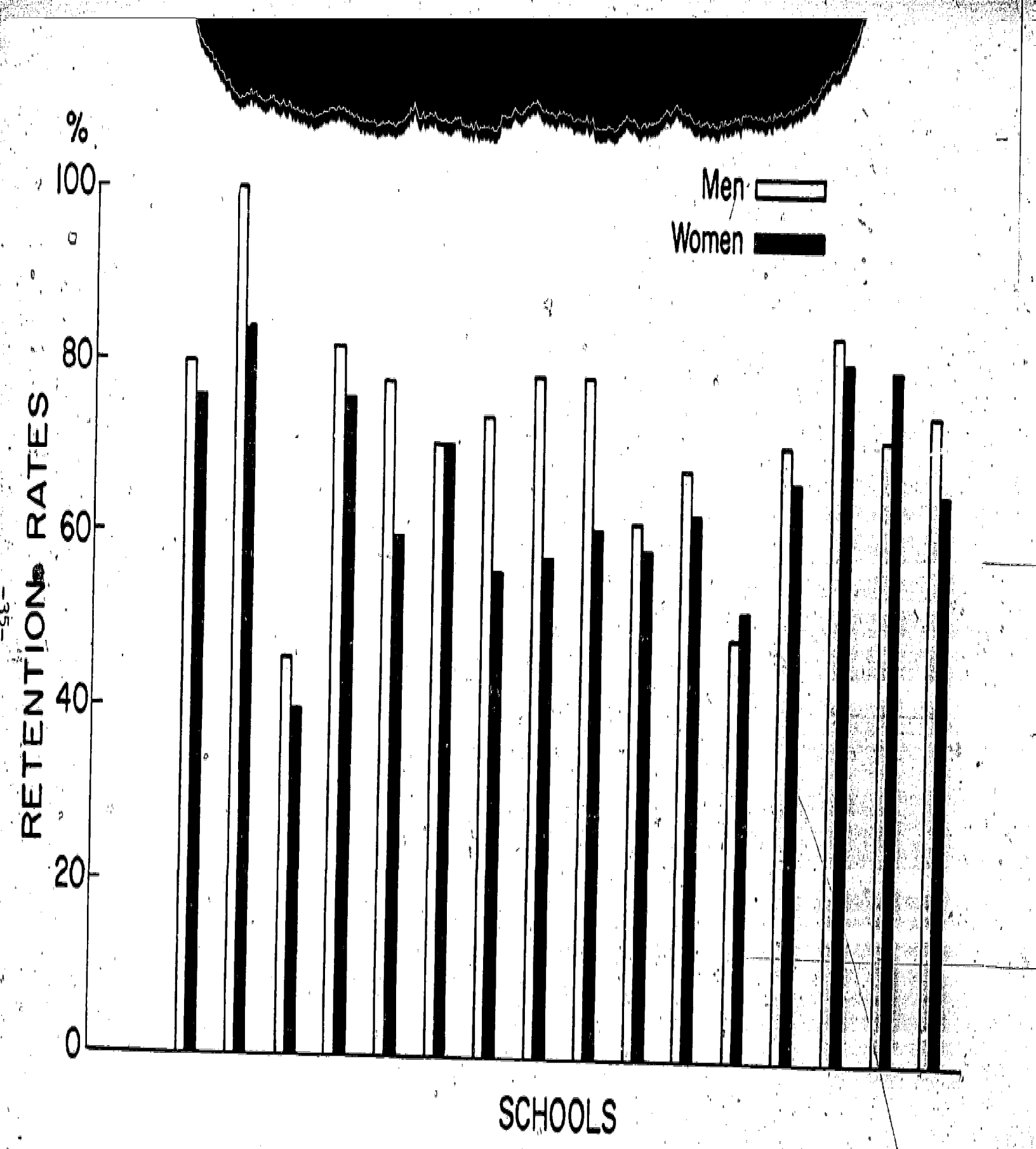

Figure 2. Retention rates for students in sample at each school, by sex of student.

Thus, based on the sample results, there was a difference in retention rates for men and women in the population, and most of the schools in the sample had somewhat lower rates of retention for women than for men. It is useful to compare the student characteristics at college entrance of the retention and non-retention groups, and to determine the destinations of students who left engineering at their original schools. These areas will now be discussed.

Summary of the Comparisons of Student Characteristics. Student characteristics were determined by means of the fall 1975 freshman survey which was completed by students in the sample at the beginning of the freshman year. Of the students contained in the sample, 55.3% (i.e., 905/1637) of the men and 60.6% (i.e., 773/1276) of the women completed the survey. As discussed earlier, the survey consisted of Part I of the College Student Questionnaire developed by the Educational Testing Service, and additional items developed for this study.

Because of the large number of differences between the characteristics of men and women at college entrance, we first compared the retention group with the non-retention group for men and women separately. We then contrasted the results for men and women.

One hundred seventy-six of the male survey respondents and 200 of the female survey respondents were in the non-retention group. Their responses to the fall 1975 survey were weighted in an attempt to reflect all of the students in the population of 42 schools who did not continue in engineering at their original schools. Seven hundred twenty-nine of the men and 573 of the women survey respondents were in the retention group. Their responses were weighted in an attempt to represent all of the students in the population who were retained.

For each sex, the responses of the retention group and of the non-retention group were compared for 37 questions and for two scales, each of

which was based on 10 items from the survey. These questions and scales were selected because previous research had identified many of the areas, such as achievement in high school and parental income, as correlates of attrition. We compared the estimated population proportions of students in the retention and in the non-retention groups who would give a specific response to a survey question. The difference in the estimated proportions for the two groups was compared with the estimated standard error of this difference to determine whether the difference in response proportions was significant at the .01 level. This level was used in order to be almost certain that differences in the sample really reflect differences in the population. For men there were statistically significant differences at the .01 level for 18 of the comparisons. For women there were 13 such differences.

The survey items which did not produce statistically significant differences for men or women included a number which were similar to items that other studies have identified as related to attrition. These items were the following: expected employment during college (Kolstad, 1977); parental income and time when the student first considered engineering (Foster, 1976); years of higher education desired (Elkins & Luetkemeyer); and mother's highest degree (Davis). Other items which did not produce differences meeting the criterion included the guidance counselor's reaction to choice of engineering, the size of the high school graduation class, and the scales giving level of cultural interest and social attitudes. It is possible that, even though the sample differences were not significant at the .01 level for these items, there were still differences in the population proportions. Also, it is possible that some of these items would have adequately distinguished between the retention and non-retention groups if students who transferred and students who left due to academic failure had been compared separately with the retention group (Hanson & Taylor; Vaughan, 1968).

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ɔared separately with the retention group (Hanson & Taylor; Vaughan, 1968).

Table 12. Responses which Distinguish Between the Retention and Non-Retention Groups for Men

RESPONSES	Estimated Proportion Giving Response: Retention Group	Estimated Proportion Giving Response: Non-Retention Group	Estimated Standard Error of Difference in Response Proportions	Estimated Retention Rate of Students with the Given Response
1. In top 90 to 94 percentile of high school class	23%	16%	2.3%	80%
2. In top 95 to 97 percentile of high school class	21	8	2.4	88
3. Had A- or A average in high school	52	34	5.3	81
4. Had A- or A average in senior year	62	40	2.7	81
5. Had B- to B+ average in senior year	36	49	4.2	66
6. Had C+ or lower average in senior year	2	10	2.6	34
7. Expect C+ or lower average in freshman year	15	28	3.0	60
8. Plan to attend graduate school in order to increase earnings	12	6	1.6	85

Table 12.(cont.). Responses which Distinguish Between the Retention and Non-Retention Groups for Men

RESPONSES	Estimated Proportion Giving Response: Retention Group	Estimated Proportion Giving Response: Non-Retention Group	Estimated Standard Error of Difference in Response Proportions	Estimated Retention Rate of Students with the Given Response
9. Interested in professional life (doctor, lawyer, etc.)	65%	57%	2.9%	76%
10. Stable, secure future as most important source of future job satisfaction	18	13	1.8	79
11. Chose from 4 or more fields in selecting engineering	15	24	2.9	63
12. Fairly important to parents that one attends college	15	24	3.1	63
13. Expect to rank in top 5 to 10% of class	27	20	2.4	78
14. Expect to do better than students of same sex	42	30	4.3	79
15. Expect to do better than students of opposite sex	48	32	3.7	80
16. Expect to do as well as students of opposite sex	47	62	3.4	67

Table 12 (cont.). Responses which Distinguish Between the Retention and Non-Retention Groups for Men

RESPONSES	Estimated Proportion Giving Response: Retention Group	Estimated Proportion Giving Response: Non-Retention Group	Estimated Standard Error of Difference in Response Proportions	Estimated Retention Rate of Students with the Given Response
17. Graduated from a public high school	85%	77%	3.0%	75%
18. Mathematics was favorite high school subject	40	31	3.1	78

Table 13. Responses which Distinguish Between the Retention and Non-Retention Groups for Women

RESPONSES	Estimated Proportion Giving Response: Retention Group	Estimated Proportion Giving Response: Non-Retention Group	Estimated Standard Error of Difference in Response Proportions	Estimated Retention Rate of Students with the Given Response
1. Had A- or A average in high school	73%	63%	1.0%	71%
2. Had A- or A average in senior year	80	64	3.7	72
3. Had B- to B+ average in high school	26	36	2.2	61
4. Had B- to B+ average in senior year	20	34	4.1	55
5. In top 80-89 percentile of high school class	10	19	2.2	51
6. Working with ideas as most important reason for choosing engineering	13	7	1.9	80
7. Chose from 2 fields in selecting engineering	33	42	3.1	62
8. Chose from 3 fields in selecting engineering	41	32	2.8	73

Table 13 (cont.). Responses which Distinguish Between the Retention and Non-Retention Groups for Women

RESPONSES	Estimated Proportion Giving Response: Retention Group	Estimated Proportion Giving Response: Non-Retention Group	Estimated Standard Error of Difference in Response Proportions	Estimated Retention Rate of Students with the Given Response
9. Extremely important to parents that one attends college	38%	31%	2.1%	72%
10. Father's highest degree is bachelor's degree	37	24	4.9	77
11. Caucasian	92	82	3.1	70
12. Did two hours or more homework per day in high school	58	51	2.3	71
13. In ten years, prefer to be married, have children, and be working part-time	27	19	3.0	75

the men in the non-retention group left due to academic failure and dismissal. However, substantial numbers of the most highly qualified men students were not retained. The men who had been in the top 2 percent of their high school class were just as likely not be to retained as were other men. To a large extent, these highly qualified men who were not retained were probably internal transfers (Elton & Rose, 1971).

There was also a relationship between prior academic achievement and retention for women. Women who had received A averages in high school or in their senior year of high school were more likely to be retained than were other women. Women who had B averages in high school or in their senior year or were in the top 80-89 percentile of their high school class were less likely to be retained than were other women. These women had lower class standings than 80% of the women freshman engineering students. Thus the women who had lower retention rates tended to have been at the lower end of the achievement spectrum of women engineering students, although their absolute levels of achievement in secondary school were high. Thus one might expect that academic failure would be a less likely reason for these women to leave engineering than for the men, and that women who left would be more likely than men to transfer into a different curriculum. The destination of non-retained students is discussed in the next section.

Self-confidence also appears to be related to retention for men. Men who thought they would rank in the top 5 to 10% of their class had a higher retention rate than did other men. Those men who thought they would do better than other men in engineering or women students in engineering had a higher retention rate than did other men, whereas those who thought they would do as well as women students had a lower retention rate than other men. For women, expectations of ones success in relation to men or to other women apparently did not differentiate between the retention and non-retention groups.

Certain background characteristics differentiated between the students in the retention and non-retention groups, although these characteristics differed for men and women. For men, we found that those who had graduated from a public high school had higher retention rates than men who did not do so. This agrees with the results of a study of freshmen at the University of Maryland (Elkins & Luetkemeyer). However, there was no significant difference in retention rates for women who had graduated from public or non-public high schools. For women, but not for men, we found that the highest degree received by the father of the student, and the student's race were related to retention rates. Women whose father's highest degree was a bachelor's degree had higher rates of retention than other women. This difference was significant also for men, at the .05 level of significance, but not at the .01 level. Women who indicated that they were Caucasian had a higher estimated retention rate than that of other women. No significant difference in retention rates for Caucasians and others was found for men. These results point out the possibility that women engineering students who are members of minority groups may encounter special difficulties (Ott, 1978).

We found that parents' attitudes to college attendance of the student were related to retention, as has been noted in earlier studies (Tinto). For men, those who said their parents considered college attendance only fairly important were less likely to be retained than were other men. A similar result was found for women. A larger proportion of women who indicated that their pa ts considered college attendance extremely important were retained than were other women. The retention rate was higher for men whose favorite high school subject was mathematics than for other men. The retention rate was higher for women who did two or more hours of homework a day in high school than it was for other women.

The number of fields from which students selected in choosing engineering was related to retention rates. For men, the retention rates were lower for those who had selected from four or more fields than they were for men as a whole. For women, the retention rates were lower for those who had selected from two fields, and higher for those who had selected from three fields, than the retention rates for all women.

Retention rates were higher for women who planned to be married, have children, and work part-time at a time ten years into the future than for other women. Women who had indicated that they planned to be married and have children and work full-time had lower retention rates. The difference in proportions giving this latter response in the retention and non-retention groups was significant at the .05 level, but not at the .01 level.

Finally, differences in motivation also appear to be related to differences in retention rates. Those men who were interested in attending graduate school in order to increase their earnings (Foster, 1975) had a higher retention rate than men as a whole. Men who were interested in a professional life, and those for whom a stable, secure future was the most important source of future job satisfaction, had a higher retention rate than men did as a whole. Women who indicated that working with ideas was the most important reason that they selected engineering had a higher retention rate than other women. (This latter result is in contrast with Elton and Rose's finding (1967;1971) that male students at the University of Kentucky who transferred from engineering scored higher than did persistors on personality scales which indicated they liked reflective thought.) Thus motivation was related to retention, although different motivations differentiated between the retention and non-retention groups for men and for women.

Thus prior academic achievement and expectations, self-confidence, type of secondary school, parents' attitudes toward college attendance,

favorite high school subject, number of fields from which one selected in choosing engineering, and motivation were related to retention for men. Prior academic achievement, father's highest degree, race, time spent on homework in high school, family-career plans, number of fields from which one selected in choosing engineering, and motivation were related to retention for women.

Destinations of Students

We have identified certain characteristics which distinguished between the students who were retained and those not retained. We will now discuss the destinations of the students who were not retained in engineering. Only those students who completed the survey were included in the analysis of student destinations.

The schools reported the destinations of 136 of the 176 men (77.3%) and of 155 of the 200 women (77.5%) in the non-retention group who completed the survey. Destinations were categorized as follows:

1. Temporary leave of absence.
2. External transfer, engineering (at another school, but in engineering).
3. External transfer, other (at another school, not in engineering).
4. Internal transfer (same school, not in engineering).
5. Academic failure and dismissal.
6. Leaving school without academic failure.

The unweighted percentages of men and of women in each of these categories are given in table 14.

From table 14 it is evident that the destinations of men and of women were quite different. A majority (68%) of the women students who were not retained were internal transfers, as were 43% of the men. Academic failure and dismissal directly accounted for the non-retention of a larger proportion of the men than of the women. This differs from Davis' finding that twice

Table 14. Reported Destinations of Survey Respondents Who Were Not Retained

	Destination	Men (n = 136)	Women (n= 155)
1.	Temporary leave of absence	5%	3%
2.	External transfer--engineering	3	2
3.	External transfer--other	7	8
4.	Internal transfer	43	68
5.	Academic failure	24	10
6.	Leaving without academic failure	18	10

as large a percentage of the women as of the men engineering students in her study withdrew with grade averages below a C (Davis).

It is quite interesting that retention of women students within a given school (rather than retention within engineering) appears to be larger than retention of men within their original schools. This is not surprising since the women had better high school achievement than the men did (Ott, 1976).

Table 14 also indicates that the difference in retention rates in engineering for men and women is not substantially affected by our inclusion of students who were on leaves of absence or who had transferred to other schools in engineering in the non-retention group.

The difference in retention rates for men and women engineering students in this population was apparently the result of higher rates of internal transfer for women than for men. It would be useful to determine the reasons for the large number of internal transfers among women engineering students.

C. Relationships Between Enrollments and Retention Rates.

One might expect to find that retention rates for women are related to enrollments of women. In table 15, we show the correlation coefficients between the retention rates of women at the 16 schools in the fall 1975 sample and (a) the number of women in the initial freshman enrollments; and (b) the percentage of women in these enrollments. These correlation coefficients do not differ significantly from zero. Thus there was no statistically significant relationship between retention rates and enrollments of women for this sample of 16 schools. However, the relationship between retention rates and the percentage of women enrolled appears to be somewhat stronger than that between retention rates and the number of women enrolled.

Table 15. Correlation Between Fall 1975

Freshman Enrollments and Retention Rates of Women (n=16)

Variables	Correlation Coefficient	Level of Significance
Retention rates of women and number of women in freshman class	+.17	.54
Retention rates of women and percentage of women in freshman class	+.35	.18

4. A COMPARISON OF THE SURVEY POPULATION WITH THE POPULATION OF U.S. UNIVERSITY FRESHMEN

This study has investigated the characteristics of men and women engineering freshmen in a population of 42 schools, 40 of which are universities. We will now discuss the ways in which these engineering students are typical or atypical in relation to other students at U.S. universities. In particular, we will discuss the similarities and differences between the women engineering freshmen and other women students at universities.

Universities, rather than two-year or four-year colleges, are used as the comparison group so that differences which are obtained can be attributed to academic major rather than to type of institution. The sources of the comparative data, unless otherwise noted, are the Cooperative Institutional Research Program's (CIRP) national norms for fall 1975 and for fall 1976 freshmen at universities (Astin, King & Richardson, 1976 and 1977). These norms are weighted estimates which represent all first-time, full-time freshmen at U.S. universities. Women were approximately 12% of the students at universities who indicated on the 1976 CIRP survey that they would probably major in engineering.

A. Comparisons

We will now compare the freshmen in the survey population to those in the CIRP population with respect to individual characteristics, family characteristics, and college plans.

Individual Characteristics

Race/Ethnicity The CIRP survey and the engineering survey used similar racial/ethnic categories in fall 1976 but not in fall 1975. Thus we will only compare racial/ethnic data for fall 1976 freshmen (see table 16). The estimated proportion of White students in the engineering survey population

Table 16. Estimated Proportions of Fall 1976 Freshmen in each Racial/Ethnic Category

Racial/Ethnic Category *	Estimated Proportions			
	Engineering Survey Population		CIRP Population	
	Men	Women	Men	Women
White, non-Hispanic	86.5%	84.4%	91.4%	89.0%
Black, non-Hispanic	2.5	4.8	5.5	8.4
American Indian	0.0	0.3	0.7	0.6
Asian	2.9	3.7	1.5	1.4
Hispanic	3.7	2.9	0.7	0.7
Other	2.0	1.9	1.4	1.0

* Categories are those used in the fall 1976 engineering survey. The CIRP used the following categories: White/Caucasian; Black/Negro/Afro-American; American Indian; Oriental; Mexican-American/Chicano; Puerto Rican-American; Other. CIRP results for Mexican-American/Chicano and for Puerto Rican-American are combined as Hispanic in this table.

in fall 1976 was somewhat lower than in the university population. We estimated that the engineering population also had a smaller proportion of Black students than did the university population, and Blacks comprised a larger proportion of the women students than of the men in each population. Although the proportions were small, we estimated that larger proportions of Asian American and of Hispanic students were in the engineering population than in the university population as a whole.

These differences in the racial/ethnic composition of the two populations reflect (1) the underrepresentation of Blacks in engineering (Alden, 1977); (2) the overrepresentation of Asian Americans in engineering; and (3) the inclusion of the University of Puerto Rico in the engineering survey sample but not in the CIRP sample.

Religion About 20% of the students in the survey population and 12% of those in the university population indicated that they had no formal religion. Catholics were represented in about the same proportions in both populations (31%). Based on our estimates, there were smaller proportions of Jewish students and of Protestants in the engineering survey population than in the university population.

Age The average age of the women students in the two populations was slightly less than that of the men. There were somewhat more women than men freshmen who were 17 years old or younger, and somewhat more men than women who were 19 years old or older.

ACT Scores Forty-two per cent of the men and women in the engineering survey population in fall 1976 reported scores on the American College Testing Program examination (ACT). These students reported scores for the Mathematics subtest and the Natural Science subtest, as well as the composite score. These scores, along with corresponding scores of 10% of all students who took the ACT in 1975-76 are summarized in table 17. For each of these

Table 17. Distributions of ACT Scores*

Standard Score	1975-76 Students		Fall 1976 Engineering Population	
Mathematics Subtest	Men	Women	Men	Women
31 to 36	5%	1%	34%	34%
25 to 30	27	16	54	54
19 to 24	22	19	11	11
Below 19	46	64	1	2
Natural Science Subtest				
31 to 36	11%	4%	42%	38%
25 to 30	28	21	40	39
19 to 24	28	30	17	19
Below 19	33	45	1	4
Composite Score				
31 to 36	1%	1%	16%	19%
25 to 30	20	13	59	54
19 to 24	33	27	23	25
Below 19	45	59	2	2

* Based on a 10% sample of all high school students tested in 1975-76 (ACT Research Services, undated), and on the data for the 42% of men and women in the engineering survey population who reported scores.

scores, the engineering survey population had very superior scores in comparison with all students who took the ACT in 1975-76 (ACT Research Services, undated). For example, 34% of the engineering population who reported scores had scored from 31 to a perfect score of 36 on the Mathematics subtest. Only 5% of all the men and 1% of all the women taking the ACT had obtained such high scores.

Among all students in the nation who took the ACT, men tended to have higher scores than women did for the three scores discussed here. In the engineering survey population, men tended to have slightly higher scores than women did on the Natural Science subtest, and essentially the same distribution of scores as women did on the Mathematics subtest and on the composite score.

Thus engineering students in the survey population achieved high scores on the ACT Math and Natural Science subtests, and a high composite score, in relation to all students who took the ACT. Scores of men and women in the engineering survey population were more similar than were scores of all men and all women who took the ACT.

SAT Scores Seventy-two per cent of the students in the engineering survey in fall 1976 reported Scholastic Aptitude Test (SAT) Mathematics and Verbal scores. These scores, along with those for all 1976 graduates who took the test, are summarized in table 18. The scores for the students in the engineering survey population were considerably better than the scores of the total group of high school seniors graduating in 1976 who took the test (Admissions Testing Program of the College Entrance Examination Board, 1976).

Eight per cent of all the men and women who took the SAT obtained Verbal SAT scores of 600 or above, in contrast with an estimated 36% of the men and 44% of the women in the engineering survey population who reported scores. The median Verbal SAT score for men engineers was in the range

Table 18. Distributions of SAT Scores*

Standard Score	1975-76 High School Seniors		Fall 1976 Engineering Population	
Mathematics	Men	Women	Men	Women
750 or above	2.0%	0.3%	16%	11%
600 to 740	21	10	69	68
Below 600	77	90	15	21
Verbal				
750 or above	0.3%	0.2%	1%	2%
600 to 740	8	8	35	42
Below 600	92	92	64	56

*Based on scores of high school seniors of the class of 1976 (Admissions Testing Program of the College Entrance Examination Board, 1976), and on the data for the 72% of the students in the engineering survey who reported SAT scores.

540 to 560; for women engineers it was in the range 570 to 590. The median score for all seniors who took the test was in the range 400 to 450 for both men and women.

Twenty-three per cent of the men and 10% of the women seniors who took the SAT received Math SAT scores of 600 or above, in contrast with 85% of the men and 79% of the women in the engineering survey population who reported scores. The median score for men engineers was in the range 660 to 680. For women engineers the median was in the range 630 to 650. In contrast, the median score for all men in the nation who took the test was approximately 500, whereas that for women was about 440.

Overall, one sees that based on our survey estimates the engineering survey population had very high SAT scores in comparison with all high school seniors who took the SAT. In the engineering population, women tended to have somewhat higher scores on the Verbal SAT than men did, although this was not true for the total group of high school seniors. Among students in the engineering survey population, a smaller percentage of women than of men obtained scores of 600 or above on the Math SAT. However, the difference in proportions between men and women obtaining such scores was smaller in the engineering survey population than in the high school senior population.

High school grade average In both the engineering survey and CIRP populations, larger proportions of women than of men had A- averages or above in high school. However, the survey population had significantly larger estimated proportions of students with A averages than did the university freshman population (see table 19). Few females and only about 4% of the males in the engineering survey population had C+ or lower averages. Approximately 13% of the men and 6% of the women in the university population had C+ or lower averages in high school. Thus the students in the engineering survey population, and the women in particular, were very high achievers

Table 19. Estimated Proportions of Fall 1976 Freshmen Having A Averages in High School

	Men	Women
CIRP Population	30%	38%
Engineering Survey Population	55%	74%

in high school, in comparison with all university freshmen.

Family Characteristics

Parents' Educational Levels The distributions of educational levels of the fathers of men and women university freshmen and of men in the engineering population were very similar. However, the fathers of women in the engineering population tended to be more highly educated than were the other fathers. Similarly, the mothers of women in the engineering population tended to be more highly educated than were the mothers of the other students. Larger proportions of the other students' mothers than of women engineers' mothers had only finished high school. Larger proportions of the women engineers' mothers than of the others had obtained some college education.

Parent an Engineer In fall 1976, but not in fall 1975, students in the engineering survey sample were asked whether their parents were engineers. Of this group, an estimated 27% of the men and 32% of the women had fathers who were engineers. This was much larger than for students in the population of university freshmen in 1976 (about 11%). Thus a much larger proportion of both men and women in the engineering survey population than of those in the university freshman population had fathers who were engineers. In both populations, only about 0.1% of students' mothers were engineers.

Parental Income Parental income was indicated by engineering survey respondents in fall 1975, but not in fall 1976. We will only discuss comparisons for the fall 1975 freshmen. For the students who responded to this question (approximately 14% of students in the engineering sample gave no response), the distributions of parental income were quite similar for the two sexes and for the two populations. Thus the engineering survey population was typical of all university freshmen in this respect.

College Plans

Highest Degree Planned In fall 1976, but not in fall 1975, students who

completed the engineering survey were asked to indicate the highest degree that they planned to obtain. A similar question was asked on the CIRP survey. The responses to this question are summarized in table 20. In the U.S. university freshman population, men were more interested than women in obtaining doctoral degrees or professional degrees in medicine, law, and so forth. A larger proportion of women than of men in the CIRP population planned a bachelor's degree as their highest degree. In the engineering survey population in fall 1976, there was essentially no difference in the proportions of men and of women planning to obtain these degrees.

Comparing the two populations, we found that the engineering survey population was more interested in obtaining master's degrees and less interested in obtaining professional degrees (e.g., in medicine or law) than were the men and women in the university population.

Expect Average of B or above Approximately 47% of the men and women students in the university population believed that their chances of obtaining a B average or above in college were good. In contrast, approximately 77% of the men and women in the engineering survey population expected B averages or above in their freshman year in college. Although the two surveys asked questions referring to different lengths of time, it appears that engineering students were more likely than the overall university freshman population to expect B averages.

As discussed in Chapter 2, larger proportions of men than of women in the engineering survey population expected A averages in their freshman year. This information is not available for the CIRP population.

Plans to Join a Fraternity or Sorority Perhaps due to the fact that women who study engineering are entering a traditionally masculine field, there has been interest in learning whether these women are more or less likely than other women to join a sorority (O'Bannon, 1975). In the university survey population, about 17% of the men and 21% of the women indicated that

Table 20. Highest Degree Planned by Men and Women in the Engineering and CIRP Populations

Survey:	CIRP		Engineering	
Degree / Group:	Men	Women	Men	Women
None or Associate	1.8%	2.9%	0.2%	0.0%
Bachelor's	30.3	38.6	34.5	37.6
Master's (M.A., M.S.)	28.9	31.9	37.1	36.1
Ph.D. or Ed.D.	13.4	10.1	13.4	13.7
M.D., D.D.S., etc.	14.4	9.4	2.5	2.7
LL.B. or J.D. (law)	9.0	5.1	2.9	3.1
Other (including M.B.A.)	2.1	1.9	7.6	6.0
No response	---	-----	1.9	0.7

chances were very good that they would join a social fraternity or sorority. Nearly 30% of the male students in the engineering survey population and 20% of the female students in this population hoped to join a fraternity or sorority.

Thus the greatest level of interest in fraternity/sorority membership was among men in the engineering survey population. Women engineering students were no more or less inclined to become sorority members than were other women in the university population.

B. Conclusions

Differences Between CIRP and Engineering Populations

Based on our survey estimates, the engineering survey population as a whole differed from the university freshman population in terms of race, ACT and SAT scores, high school averages, numbers of fathers who were engineers, level of degree desired, grades expected, and possibly religion. There were no apparent differences between the two populations as a whole in distributions of ages or of parental income.

The differences in race are probably attributable to the racial composition of the engineering student population in the U.S. (Alden) rather than to special characteristics of the engineering survey population. However, the larger proportion of Hispanics in the engineering survey population is apparently due to the inclusion of the University of Puerto Rico in this survey but not in the CIRP survey.

The differences in high school averages, grades expected, advanced degrees desired, and numbers of fathers who are engineers are probably due to the differences in major fields of students in the two populations, rather than differences in schools included in the populations.

Differences Between Men and Women in Each Population

There were differences which were similar for both the CIRP and engineering survey populations between the characteristics of men and of women:

(1) Blacks comprised a larger proportion of the women students than of the men in each population.

(2) Women's ages averaged slightly less than men's.

(3) Larger proportions of women than of men attained A averages in high school, and smaller proportions of women than of men had C+ averages or lower in high school.

(4) Larger proportions of men than of women obtained high scores on the Natural Science subtest of the ACT, and on the Math SAT.

Differences Characteristic of Women Engineering Students

There were other characteristics which differentiated women engineering students from the other students:

(1) Women engineering students' parents tended to be more highly educated than the parents of the other students.

(2) Women engineering students had extremely good high school grade averages.

The first of these characteristics suggests that more highly educated parents are more supportive of their daughter's intention to major in a field such as engineering. The second characteristic indicates that women engineering students are among the best qualified students at U.S. universities.

5. A COMPARISON OF BLACK WOMEN AND WHITE WOMEN ENGINEERING FRESHMEN

There is currently a great deal of interest focused on minorities and women within the professions, such as engineering. However, studies of minorities or of women in engineering have not generally considered women minorities separately. Nevertheless, women who are members of minority groups may face special problems when they aspire to a career in engineering, for they are unlike the majority of engineering students both in regard to race and in regard to sex (Malcom, Hall & Brown, 1976). Therefore, as part of this study, we compared data obtained from Black and from White women for the fall 1975 and fall 1976 surveys.

There were a number of reasons for focusing on Black women, rather than other minorities. Blacks, who comprised about 11.1% of the U.S. population in 1970, were only about 1.2% of all professional engineers, making Blacks the most underrepresented racial or ethnic minority in engineering in the United States (Planning Commission for Expanding Minority Opportunities in Engineering, 1974). Moreover, a larger number of Black women than members of other minority groups participated in the survey project. In fact, the numbers of responses from other minority students were too small to allow for the calculation of reliable estimates of population response proportions. White women, rather than all non-Blacks, were used as a comparison group because Whites constitute the majority group among women engineering students.

We will discuss those estimated proportions which were found to be significantly different for Black and for White women. These differences have implications for student recruitment and for the provision of supportive services.

A. Method

Participation Rates and Estimated Population Proportions

In fall 1975, 773 women completed the survey, including 682 who identified themselves as Caucasian. Forty women identified themselves as Negro, including 14 from the predominantly Black institution. In fall 1976, 852 women completed the survey, including 686 who identified themselves as White, non-Hispanic, and 57 as Black, non-Hispanic. Ten of these Black women were from the predominantly Black institution. Thus the total number of Black women who were survey respondents was 97. (The question identifying race was changed for the fall 1976 survey to conform with HEW racial/ethnic categories.)

Women comprised an estimated 15.1% of the survey population of approximately 19,300 students in fall 1975, and an estimated 16.0% of the survey population of approximately 21,400 students in fall 1976. Estimates of the proportions of these women who were White and the proportion Black for these two populations are given in table 21.

Analysis

The fall 1975 and fall 1976 surveys were analyzed separately. Data were analyzed in terms of estimates of the proportions of Black and of White women in the population (42 schools) who would have a given response to a question. In order to make valid estimates of these population proportions, the data were weighted, including adjustments (1) to reflect overall selection probabilities; (2) to account for student nonresponse; and (3) in fall 1976, to account for non-participation of two schools.

We calculated the estimated standard errors of the differences between the estimated proportions for Black and for White women giving a certain survey response. By comparing the difference in the estimated proportions of Black and of White women giving a certain response with the estimated standard error of the difference, we determined whether the differences in estimated proportions were statistically significant at the .01 level. We

Table 21. Estimated Population Proportions of Whites and of Blacks among Women Engineering Freshmen.

	White Women	Black Women
Fall 1975	88.7%	4.1%
Fall 1976	84.4%	4.8%

will discuss only those differences in estimated proportions which were statistically significant at the .01 level for both the fall 1975 and fall 1976 surveys.

B. Results

The estimated weighted proportions of Black and of White women giving a certain response to a question are given in table 22 for those items for which there were significant differences both in fall 1975 and fall 1976. In brief, these results indicate:

(1) Fathers were more influential in the student's decision to pursue engineering for White women than for Black women.

(2) Guidance counselors were more aware of, and supportive of, the engineering interest of the Black women than of the White women.

(3) Black women were more likely than White women to support special assistance for minority engineering students.

(4) Fathers of White women were more likely than those of Black women to have graduated from college.

(5) The majority of Black women had high school grade averages ranging from B- to B+, whereas the majority of White women had averages of A- to A+.

C. Discussion

These results have implications for the recruitment of Black women, and for the provision of supportive services.

Recruitment

The major avenues available for recruiting Black women and White women for engineering are parents and other family members, high school personnel, college personnel, other students or acquaintances in engineering, and promotional advertising. In this study, we have found differences between Black women and White women in the effectiveness of two of these sources--students' fathers and high school guidance counselors.

Table 22. Responses Indicating Differences Between White Women and Black Women

RESPONSES	Estimated Weighted Proportions			
Survey:	Fall 1975		Fall 1976	
Group:	White Women	Black Women	White Women	Black Women
1. Student's father was most influential person in choice of engineering as major	26.0%	3.2%	35.9%	3.4%
2a. Guidance counselor was largely unaware of student's interest in engineering	29.7	4.7	34.7	17.3
2b. Guidance counselor mildly or largely supported student's interest in engineering	64.6	87.1	60.1	74.3
3. Do not support special assistance for minority engineering students in academic skills, laboratory skills, study skills, career guidance, academic enrichment or college sponsored peer support groups	40.7	8.7	33.2	3.6
4. Student's father graduated from college	61.1	13.5	61.9	32.6
5a. High school grade average of B-, B, or B+	26.5	74.2	24.2	63.4
5b, High school grade average of A-, A, or A+	72.5	23.4	75.1	30.2

As indicated in table 22, fathers of White women were more likely than fathers of Black women to have been the most influential person in the selection of engineering as a major field. This difference is largely explained by the fact that a much larger proportion of White women's than of Black women's fathers were engineers. In fall 1976, the estimated proportions whose fathers were engineers were 35.5% for White women and 1.2% for Black women. Furthermore, of the White women who indicated that their fathers were most influential in their choice of engineering, 69.4% had fathers who were engineers. Thus the fathers who influenced White women to study engineering tended to be engineers themselves.

Whereas White women may be recruited to study engineering by fathers who are engineers, it is clear that this method would be largely ineffective for Black women. Therefore, greater efforts are needed from high school or college personnel to identify and encourage Black women to study engineering. In addition, there appears to be a special need for engineers to visit junior and senior high schools to discuss their profession with Black students.

It is important in this regard that the Black women in the survey population appear to have found support from their high school guidance counselors in their decisions to pursue engineering. The data in table 22 concerning guidance counselors seem to indicate that few Black women chose to study engineering who did not receive the interest and support of their high school guidance counselors. Whichever way one interprets these results, it is clear that guidance counselors played a more important role for the Black women than for the White women engineering freshmen.

College Support Services

In regard to support services, it is important to recognize that there are both formal and informal channels of support which may assist students.

White students may have greater access than minority students to informal channels of support, such as fathers who are engineers, other engineering students, and faculty and other professional engineers. These informal channels can provide information on the nature of engineering, help in connecting theoretical subject matter with the practice of engineering, and guidance in obtaining jobs. Such information can provide a framework into which students can fit their college experience and may carry them through dry periods. Minority students, on the other hand, may need the help of formal supportive services in these areas because the informal channels are not as available to them. It is possible that the informal networks are also more accessible to male students than to females, placing minority females in a particularly difficult position.

The majority of both Black women and White women supported the idea of assistance for minority engineering students, in areas such as academic skills, laboratory skills, study skills, career guidance, academic enrichment, or college sponsored peer support groups. Few Black women were opposed to special assistance for minority students. Thus it appears that the provision of special support services for minority students would be viewed very favorably by Black women, although many White women may be opposed to the offering of special services to minorities.

In terms of two types of assistance generally provided by colleges--financial aid and tutorial assistance--responses to the surveys indicate that Black women in the population had greater needs than White women.

A smaller proportion of Black women's fathers than of White women's had graduated from college. (It is interesting to note that the proportion of mothers who were college graduates did not differ significantly by race. About 35% of the students' mothers had graduated from college.) The difference in the educational levels of the fathers of the students points toward possible differences in the ability of the students' families to pay college

expenses. This possibility is borne out by students' responses to a question on the fall 1975 survey concerning their major source of financial support (table 23). It appears that financial aid is more crucial to Black women than to White women for entrance and continuation in an engineering program.

Finally, on the average, the White women in the survey population received higher high school grades than did the Black women. The majority of White women attained A averages; the majority of Black women attained B averages. The reason for this difference in grade averages is unclear. It may be that few White women with B averages are encouraged to consider engineering as a career. Whatever the reason for the difference, it appears that a larger proportion of Black women than of White women engineering students may require tutorial assistance in college.

Table 23. Major Sources of College Financial Support, Fall 1975

Sources of Support	Group	
	White Women	Black Women
Parents	64.8%	6.7%
Scholarships	17.1%	76.7%

6. POLICY IMPLICATIONS FOR ENGINEERING COLLEGES

The survey and retention results which have been presented have important implications for engineering colleges, since a substantial proportion of today's engineering students are women. The differences between men and women engineering students which were found in this study indicate that women students have many positive characteristics which should benefit and diversify the profession. However, to accommodate the differences between men and women in interests, experiences, expectations, and so forth, engineering colleges will need to change. We will now discuss the implications of the survey and retention results.

A. Implications of Survey Results

Recruitment

Women engineering students tended to first consider majoring in engineering in their junior or senior year of high school. Thus one might consider focusing a recruitment program on girls in the 11th and 12th grades. However, it is likely that many girls with the aptitude to study engineering do not do so because they stop taking mathematics early in high school (Sherman & Fennema, 1977). Then if they consider engineering as a career, they do not have the required mathematics background.

Therefore it appears that a two stage process would be more effective for recruiting high school girls into engineering. The first stage would acquaint 9th and 10th grade girls with the value of mathematics for pursuing a wide range of careers, including engineering. The second stage would focus on girls in the 11th and 12th grades. It would acquaint them with engineering as a field of study and as a career.

Peer Support

Women students tended to be very high achievers and hard workers in high school. However, at the beginning of the freshman year, women tended to have lower expectations for performance in college than men had. Moreover, at the end of the freshman year, greater proportions of women than of men underestimated the academic performance of engineering students of their own sex.

Since women indicated more frequently than men that they consult with close friends about important decisions, peer support groups such as the Society of Women Engineers, which provide contact with other women engineering students and opportunities for leadership, may be effective in helping women become more self-confident. Increased efforts to acquaint women students with each other are clearly needed, since about 40% of the women had no close friends among women students in engineering.

Non-Technical Courses

Women students' interest in the arts and in reading novels, poetry, and other literary works indicates that there may be a particular need to provide continued opportunities to take courses in the humanities. Most engineering colleges provide adequate opportunities for students to take these courses as electives. However, a few schools' curricula are rather narrowly confined to technical subjects. These schools need to broaden their allowed courses to accommodate the non-technical interests of many of their women students.

One of the schools in the study which does not offer non-technical majors has developed a program to permit students to take a year's leave of absence during the sophomore year in order to enroll in non-technical courses at another university. Both men and women students have taken advantage of this program.

Mechanical and Electrical Skills

Women students tended to prefer mathematics to science in high school. Moreover, a much lower proportion of women than of men were interested in majoring in electrical engineering. These two characteristics signal a need for women to develop more positive attitudes toward laboratory work. One cause of negative attitudes toward laboratory work may be little practical experience with mechanical and electrical skills. An improvement of attitudes toward laboratory work may be accomplished by means of a brief, concentrated course in basic electrical and mechanical skills, such as those offered at Cornell University (Hall & Hall, 1975) and at Purdue University (Butler, et. al., 1977).

Field Choice

The fact that much smaller proportions of women students than of men choose to major in electrical engineering indicates a need for studies to determine causes of this situation and remedies for it. In fact, there is a need to study reasons for decisions about field choice for both men and women students.

Academic Counseling and Career Guidance

Women students' degree of motivation to be engineers was more changeable than was men's. This is probably a reflection of the fact that a significantly larger proportion of women than of men decided to study engineering within two years of college entrance. Also, men indicated more often than women did that they had understood the nature of an engineering career before entering college. Women students, it appears, may have been less certain of their choice of engineering when they entered, and thus more subject to changes in motivation.

Therefore, women students may be in particular need of academic counseling and of opportunities to work in engineering jobs while under-

graduates. Cooperative work-study programs may be of particular benefit to women. Special programs such as Project VIEW at Cornell University are also important. Project VIEW is a program in which sophomore women and minority students spend a week visiting an engineering company. The visit reinforces the technical and professional interests of minority and women students.

Career Placement

As far as specific plans for careers are concerned, it appears that women and men have somewhat different time frameworks in mind. Although many women seem to be planning careers which follow the traditional male career pattern, the career plans of a large number of women will require more flexibility from employers than is now common. The two major requirements for furthering the careers of these women seem to be opportunities for part-time employment, and retraining after extended leaves of absence. Engineering colleges' placement personnel should assist women students who want to locate employers who are flexible in these regards.

Work Characteristics

There were additional differences between men and women which may affect the engineering profession should they persist when these students become professional engineers. That is, women and men differed somewhat in regard to the characteristics of work which they considered important. These differences reflect the traditional role expectations of men and women -- men tended to be more concerned with income and financial security, women with aiding society. It would be interesting to determine whether these differences are maintained as men and women are socialized by their education and work experience into the role of professional engineer.

Role Models

This study did not throw much light on the question of role models. For example, we do not know what effect women faculty had on the aspirations of women engineering students. However, programs which enable students to meet women engineers appear to be useful.

B. Special Implications for Educating Black Women

In addition to the implications of the research for educating women in general, there are important implications for the recruitment of Black women, and the provision of supportive services to them. These have been discussed in Chapter 5. To reiterate:

Recruitment

Many White women have been recruited to study engineering by fathers who are engineers. This method would be largely ineffective for recruiting Black women because few of them have fathers who are engineers. Therefore, greater efforts are needed from high school and college personnel to encourage Black women to study engineering.

A number of the institutions included in this project provide special programs for junior and senior high school students from minority groups. Some of the programs include the students' teachers, guidance counselors and parents. There is also a need for practicing engineers to visit junior and senior high schools to discuss the profession with Black students.

Support Services

White students may have greater access than minority students to informal channels of support, such as fathers who are engineers, other engineering students, and faculty and other professional engineers. Minority students, and particularly women minority students, may need the help

of formal supportive services to learn about the nature of engineering, to see the connections between the theoretical subject matter and the practice of engineering, and to receive guidance in obtaining jobs. Black women appear to have greater needs in terms of financial aid and tutorial assistance than other women have. Black women students tend to view the provision of special support services very favorably.

C. Implications of Retention Results

The results of the retention analysis indicate that the estimated retention rates in engineering after 1 1/2 years were significantly different for men and women (73.3% for men, 67.8% for women). Whether a difference in retention rates in engineering of about 5.5% is large enough to be of practical significance is another matter. The important point is that engineering college personnel ought to analyze the retention situation for men and women at their institutions. If there is a large difference in retention rates, steps should be taken to learn why such a difference exists. College personnel should also look into reasons for the high rate of internal transfer of women in engineering, to see whether changes need to be made in the engineering program.

One possible method for increasing retention rates is to increase the number and percentage of women students. This increase would presumably make it easier for women engineers to become acquainted with each other. In addition to support groups such as the Society of Women Engineers, another method of acquainting women engineering students with each other is "clustering" women engineering freshmen in the dormitories. Women engineering students are still a sufficiently small proportion of women students at most universities that random assignments to dormitory rooms would generally provide no more than one or two women engineers on a given dormitory floor. Clustering is an assignment method whereby most freshman women engineering students live on dormitory floors with five or six of their peers.

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